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APOLLO MONTHLY PROGRESS REPORT (U)

NAS9-150

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Report Period
July 16 to August 15, 1964

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

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ILLUSTRATIONS

TABLES

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PROGRAM MANAGEMENT

STATUS SUMMARY

The command modules for boilerplates 16 and 26 were shipped to the Kennedy Space Center during the report period. The shipping dates represented delivery some 13 weeks ahead of schedule for boilerplate 16 and on schedule for boilerplate 26. The launch escape subsystems (LES) for both boilerplates are to be shipped during the next report period.

The earth landing subsystem (ELS) parachutes for boilerplate 23 were received from Northrop-Ventura during the report period; they were delivered to WSMR on August 6.

The prototype telecommunications equipment (Collins Radio) was delivered to S&ID, and installation in boilerplate 14 was started.

The heat shield for spacecraft 006 was shipped to Avco, Wilmington, Massachusetts, during the report period. Some damage to the heat shield, considered reparable, was sustained during the truck shipment.

Manufacturing was started on the crew compartment heat shield of spacecraft 008 during the report period.

APOLLO CONTRACTS

Supplemental Agreements, Contract NAS9-150

Supplemental Agreement 24, incorporating MDS-8, has been executed by S&ID and NASA and returned to S&ID for distribution.

Supplemental Agreement 36, amending the inspection, acceptance, and delivery clause as it relates to integrated testing of GSE, has been executed by S&ID and NASA and received by S&ID for distribution.

Supplemental Agreement 37 has been executed by S&ID and NASA and received by S&ID for distribution. This supplemental agreement requires items purchased for use in manned space flight to be of the highest quality. This clause is to be inserted in all subcontracts down to the lowest tier.

[redacted]

Supplemental Agreement 41, entitled "Common Use and Concurrent Use of GSE," has been executed by NASA and returned to S&ID for distribution.

Supplemental Agreement 42 has been executed by S&ID and NASA and received by S&ID for distribution. This supplemental agreement calls principally for the provision of rendezvous radar and transponder with associated displays and controls as Government-furnished equipment.

Boilerplate 22

A contract advice was issued during the report period to provide a plan of action for the resumption of effort on the boilerplate 22 service module. The service module was shipped to Houston in an incomplete configuration; it has now been returned as Government-furnished property.

TEST SITE ACTIVATION AND LOGISTICS

Interim lines for the electrical power subsystem/environmental control subsystem (EPS/ECS) fluid system are being installed at Downey; installation is scheduled for completion on August 28. Bid award for installation of the complete EPS/ECS system is also scheduled for August 28.

To evaluate the first polarity checker, NASA has directed an initial functional test at Downey prior to shipment to Kennedy Space Center (KSC). Tulsa design personnel indicate that all polarity check components and accessory GSE equipment necessary to support functional testing will be available at Downey between August 15 and September 1, 1965. The temporary installation of these items is to be completed by October 1, 1964, when the engineering development laboratory will assume responsibility and conduct the functional tests.

Acceptance checkout equipment (ACE) station 1 at Downey completed the 72-hour check during the report period. The equipment for computer room 2 has been received and installed and is in sub-unit checkout.

A formal review of the drawings and specifications for the fluid distribution system test preparation building at WSMR was held by NASA and S&ID.

DEVELOPMENT

SYSTEMS DYNAMICS

Aerodynamics

The boilerplate 13 postflight analysis was completed. Good aerodynamic data on the launch environment test were obtained from the Q-ball. The flight data indicate a more severe boost pressure environment than predicted. Although this does not appear critical, only minimal data were obtained, and further investigation was begun. Good correlation between predicted and actual internal pressure of the service module was obtained, confirming the venting analysis. Separation of the launch escape subsystem (LES) was verified visually and with motion pictures.

The feasibility of retaining the LES, with canards, throughout the entire high-altitude abort mode for unmanned missions was studied. In this mode, the canards could orient the vehicle for the descent phase; the LES, with canards, could then be jettisoned at 25,000 feet. Data were generated to define the loads and the temperature environment on the LES for aborts at very high altitudes. Preliminary results indicate that peak decelerations will not be excessive and that this method appears feasible.

Load data for canard deployment were obtained from force and pressure measurements using the 0.15-scale model in the trisonic wind tunnel at NAA, Los Angeles. The tests were conducted at Mach numbers from 0.7 to 2.0 over an angle of attack range of -120 to +90 degrees. Model design was completed, and the assembly of component parts was begun for the dynamic stability 0.059-scale model. This model will provide the aerodynamic damping characteristics of the LES canard configuration at subsonic and low supersonic Mach numbers.

Static force tests were completed in the wind tunnel at Arnold Engineering Development Center (AEDC) using the 0.045-scale models of the launch escape vehicle, with and without canards, and models of the command module with protuberances. Data were obtained through a 360-degree angle of attack range at Mach numbers of 1.5 to 6.0.

Docking and Earth Landing

Boilerplate 1 drop tests 72 and 73 were satisfactorily completed. The purpose of these tests was to verify the stability of the revised test facility platform and harness before the first boilerplate 28 drop. The change was made to accommodate high pitch angles and high horizontal velocities.

A parachute drop test was conducted on July 20 with two drogue parachutes, each having 40 percent active reefing and 57 percent passive reefing. Both drogue parachutes deployed normally, and the test was successful. This configuration will be used on boilerplate 23.

The postflight tests on the backup abort timer for boilerplate 12 were completed. The premature timer function that occurred on boilerplate 12 was duplicated in the power drop-out test. This malfunction had resulted from a hot-line circuit short caused by the shaped charge that terminated the thrust of Little Joe II. If this should occur on boilerplate 23, resultant battery voltage drop may inhibit the motor switch operation for the separation of the command and service modules. Limit resistors are being added in the hot-line circuit for boilerplates 22 and 23 and spacecraft 002 and 010 to eliminate this problem.

MISSION DESIGN

The trajectory and flight dynamics analysis of boilerplate 13 was completed. The spacecraft demonstrated structural integrity and compatibility with the launch vehicle during the mission. The test was considered successful and representative of Saturn-Apollo flight.

An analysis of the velocity uncertainties of the entry monitor subsystem (EMS) was completed. A summary of the uncertainty sources and their effect on total velocity uncertainty is presented in Table 1 for a nominal trim angle of attack of 155.5 degrees with a lift-to-drag ratio (L/D) of 0.4.

The uncertainty sources (referenced by number in Table 1) are analyzed as follows:

1. The initial velocity is projected by the Apollo guidance computer from the last on-board navigation sighting to a nominal radius at which an acceleration load factor of 0.05 g is experienced. Uncertainties in V_0 arise from uncertainties in both the navigation sighting and the point at which 0.05 g occurs.

Table 1. Entry Monitor Subsystem
Velocity Uncertainties

No.	Uncertainty Source	Optimum Acceleration Orientation (fps)	X-Axis Acceleration Orientation (fps)
1	V_o (initial velocity) determination	15^2	15^2
2	ΔV losses (gravity, earth rotation)	56^2	56^2
3	ΔV losses (aerodynamic, center of gravity, and accelerometer orientation)	261^2	276^2
4	V_o manual setting	50^2	50^2
5	ΔV losses (acceleration measurement, integration, and display)	70^2	70^2
	Totals Root sum squared	281^2	294^2

2. ΔV losses due to gravity and earth rotation occur because the EMS mathematical model neglects gravity and does not resolve accelerations to the inertial velocity vector. This term represents the remaining velocity uncertainty during supercircular velocity flight following the application of a correction factor.

3. Other ΔV losses are related to aerodynamics, center of gravity location, and accelerometer orientation. The EMS obtains velocity data by orienting a single accelerometer to measure drag acceleration on a fixed trim vehicle. Uncertainties in trim angle, center of gravity, drag and lift polars, and the orientation angle itself give rise to velocity uncertainties. These data are based on trim uncertainties of ±4.0 degrees trim angle of attack (including center of gravity uncertainty), ±5 percent in L/D, and ±1.0 degree in accelerometer orientation.

4. Uncertainties arise from manual V_o setting, reflecting the astronaut's ability to set the initial velocity into the EMS accurately.

5. Finally, uncertainties in acceleration measurement, integration, and display exist because of hardware.

Significant conclusions drawn from these data are as follows:

1. The EMS accelerometer orientation could lie along the X-body axis, because the optimum orientation lies within a ±15-degree band of the X-axis and only a small increase in velocity uncertainty results from an X-axis orientation.

2. The greatest source of velocity uncertainty is due to aerodynamic considerations and not to subsystem hardware.

Preliminary lunar mission requirements were prepared for the command and service module subsystems specification for Block II vehicles. Recent changes in the mission concept are included. The 8.3-day design reference mission, as defined by the Apollo Mission Planning Task Force, was selected for use in reliability and performance reporting and as a design basepoint. The 10.2-day lunar orbital rendezvous mission will be used to determine the requirements of subsystems for Block II vehicles.

CREW SYSTEMS

Work is in progress on the Block II crew task interface control document (ICD). This ICD will define methods for the preparation of task analysis data including computer data entry, internal analytical procedures, and definitions of specific terminology. This document, when approved, will be the basis for an exchange of comparable data between S&ID, NASA, MIT, and Grumman. The anticipated completion date is late September.

A proposal was prepared for the evaluation of the toxic hazards of command module materials combining the animal testing program with the chemical analyses of material outgassing. This combined test program will cost less than previous estimates for chemical testing alone. Approximately 450 different materials may require testing.

Heat and light filters for the command module windows will be combined into single filters. This redesign will permit each window filter to be stowed in an adjacent-mounted roller.

Flammability tests of certain nonmetallic materials in zero-g environment were conducted at Wright-Patterson Air Force Base. All test objectives were met during approximately 40 parabolic flights in the KC-135 aircraft zero-g laboratory. Preliminary results indicate the following conclusions:

1. Flame is suppressed at zero-g.
2. Convection currents appear nonexistent, and diffusion of oxygen to the flame appears to be retarded for continued burning.
3. Slight acceleration causes convection to reappear.
4. The higher the g-load, the greater is the rate of burning.

STRUCTURAL DYNAMICS

Methods of obtaining a single-point static flotation attitude for both Block I and Block II vehicles were studied. The study was directed toward finding one design that would prevent vehicles of either type from assuming the overturned stable position. Because the current Block II design has a different shape in the center hatch docking area, the buoyancy characteristics in the overturned stable position are unlike those of Block I. One flotation bag of reasonable size, sufficient to provide single-point flotation stability for Block I vehicles, would probably not be adequate to solve the problem for Block II vehicles. For this reason, arrangements of two and three bags are being studied.

The change to water landing as the primary mode introduced a wider variation in water landing parameters. This necessitated a reexamination of the drop tower pool facility to assure the capability to simulate the most severe combination of water impact conditions likely to be encountered. Testing at higher pitch angles and greater horizontal velocities, for example, will require increasing the maximum pool depth from 10 feet to 18 feet.

STRUCTURES

The two service module oxidizer tanks, which had been tested for creep, were emptied and flushed with water on July 27. The manhole door of one tank was removed, and the butyl rubber O-rings were examined. The seals from the open tank had been saturated with nitrogen tetroxide (NTO) and released a red NTO vapor. After about three minutes, blisters formed on the O-rings and then broke; these blisters were caused by the rapid vaporization of NTO within the O-rings. The outer O-ring seal was swollen to the extent that it was approximately 1 inch larger in diameter than the groove in the tank door. The inner or primary O-ring seal remained in its groove. Cross-sectional measurements of the NTO-swollen O-rings revealed that they had taken a 3 percent compression set. The rings had been exposed to NTO for 47 days, 28 of these days at 240 psig. No leakage occurred during the test.

A space radiator in the environmental control subsystem (ECS) for spacecraft 008 was salvaged by employing an unusual reinflation and rework procedure to correct a collapsed tube condition. The success of this procedure indicates that it may become a standard practice in radiator fabrication.

An oxidizer tank was successfully burst at 446 psig at the Allison Division of General Motors. This demonstrates a +0.240 margin of safety over the design ultimate of 360 psig. The lower and upper domes each blew out 360 degrees circumferentially. The upper dome initially failed near the Y-joint; the lower dome failed halfway between the Y-joint and the access door opening. This tank had been tested in the following sequence: proof, leak, shock, leak, skirt static load, leak, creep, and burst.

GUIDANCE AND CONTROL

An engineering evaluation is being conducted to eliminate restriction of astronaut hand movement in the operation of the rotational hand control as identified at the design engineering inspection. A 10-degree down-tilt at the forward end of the rotational hand control appears to minimize the restriction. A mock-up with adjustable support for the rotational hand control will be provided to determine the optimum position of the hand control. A mock-up review by NASA will be held, and approved changes will be implemented.

A docking study was completed at Columbus to determine propellant consumption, engine duty cycles, stabilization and control subsystem (SCS) characteristics, and subsystem performance for maneuvers during subsystem malfunctions. Preliminary results were presented to NASA-MSC at Houston. The results indicate that sighting aids mounted on the lunar excursion module would be required to perform a satisfactory docking maneuver. The study also showed that, during transposition docking, an S-IVB rotational rate no greater than 0.1 degree could be tolerated. A report is being prepared for release during the next period.

TELECOMMUNICATIONS

Three bench maintenance equipment (BME) models, the C-band transponder, the S-band equipment, and the communications equipment (for testing VHF/AM, VHF/FM, and other spacecraft communications equipment) were received; they are undergoing engineering evaluation and calibration. The television BME was also received, and the up-data link BME is scheduled for delivery in late September.

S&ID awarded 90-day study contracts to both Hughes and General Electric to determine the best approach for developing an Apollo high-gain antenna for Block II spacecraft. These studies are scheduled for completion by the end of October.

The spacecraft console for the Apollo telecommunications engineering evaluation console (ATEE), formerly known as the spacecraft-GOSS instrumentation test subsystem (SGITS), was received. Modifications are being incorporated to update the console to the latest equipment configurations; preliminary testing was started. Figure 1 shows the ATEE test facility.

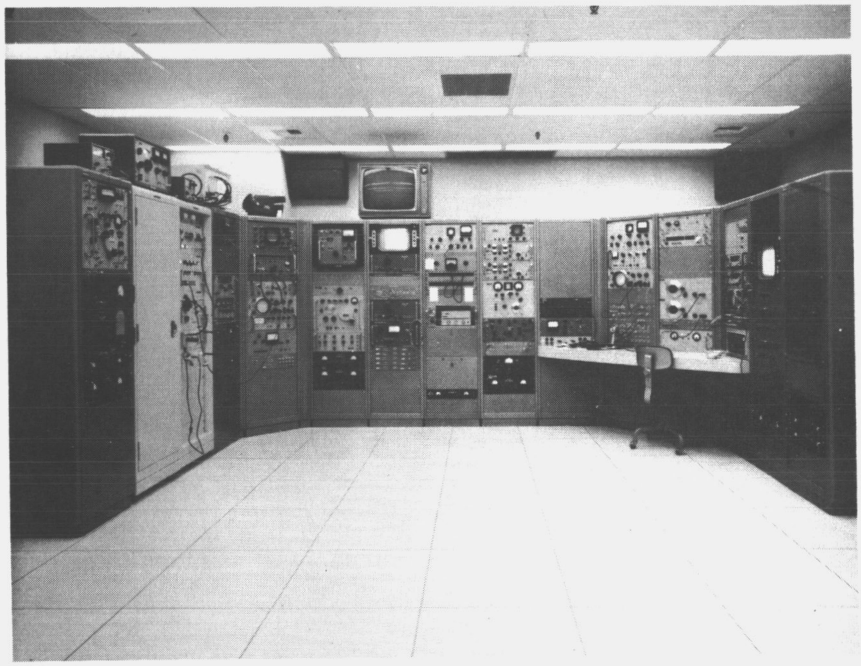

Figure 1. Apollo Telecommunications Engineering Evaluation Test Facility

Requirements and ground checkout of Block II rendezvous radar are being coordinated with associated subcontractors. The location of rendezvous radar transponder equipment installation in the command and service modules is of prime interest. Antenna coverage requirements based on command and service module attitude constraints are being generated.

Instrumentation equipment lists were frozen for boilerplates 14, 22, and 23, and for spacecraft 001, 002, and 010. Slight changes are required to bring spacecraft 009 to the frozen configuration; a review of spacecraft 008 and 011 is in progress. Wiring schematics for spacecraft 001, 006, 009, and 011 flight qualification measurements were completed.

ENVIRONMENT CONTROL

A two-dimensional thermal analysis was made to determine the peak surface temperatures on the 0.7-inch thick fused quartz windows of the command module during reentry. The results indicate these peak temperatures: crew hatch window 1670 F, side windows 1250 F, docking windows 995 F. These temperatures are below the allowable maximum of 1800 F; temperature gradients, however, are severe.

Preliminary analysis of the control programmer for spacecraft 009 indicates that the equipment will operate within design limits without the use of liquid cooled coldplates.

A proposed concept for postlanding ventilation was selected. The proposed method will use a water-cooled garment combined with forced ventilation to remove humidity and carbon dioxide. This concept was presented to NASA on July 28, concluding the first phase of the postlanding ventilation study.

Two separate water-glycol systems, one containing a corrosion inhibitor, were examined to obtain comparative data. After three weeks' exposure of a coldplate to uninhibited water-glycol in a dynamic closed loop, the fluid was found to have a metallic content of 1000 parts per million (ppm). Another loop using inhibited glycol showed a count of only 4 ppm after three months' exposure; however, there was a heavy buildup of organic sludge. The latter loop used a large amount of plastic tubing, with a glass reservoir for observation purposes. Previous testing has indicated that exposure to light causes a chemical breakdown of the inhibitor and creates an organic precipitate. This sludge will probably not be present in a normal system which is closed from direct light.

Evaluation of insulation materials for suit circuit ducts is continuing. One vendor recommended a silicon molded fiber glass insulation made in two halves. This material is coated on the inside and edges with a Dow Corning silicon rubber material, and outside with an aluminized fiber glass covering. Samples of this material will be evaluated by S&ID.

ELECTRICAL POWER SUBSYSTEM (EPS)

Electrical Power

Preliminary results of a special Block II study at Beech to further reduce heat-leak rates of the cryogenic storage tanks show, for the hydrogen tank, a rate reduction from 7.8 to 4.1 Btu per hour at an ambient temperature of 130 F. The new insulation concept employs a regeneratively cooled heat shield mounted between inner and outer tank shells, with the space between the shells vacuum sealed. The shield consists of a fin, with cooling coil attached, through which the supply gas passes. Multilayer insulation is used in only 4 percent of the area to afford support between the shells. The higher boiling point of liquid oxygen makes the incorporation of this concept in the oxygen storage tank unnecessary. This technical breakthrough will eliminate the need to provide venting in the supercritical gas storage subsystem of Block II space vehicles during the mission phase.

A solenoid-actuated orifice will be added to the fuel cell fluid subsystem for each powerplant to allow direct control of the pressure differential between the reactants (gaseous hydrogen and gaseous oxygen) and the reference gaseous nitrogen. This control is necessary because the fuel cell startup procedures require the varying of pressure differentials. The addition of this control allows startup and shutdown of individual fuel cell powerplants and removes the need for significant GSE changes.

A circuit was designed to prevent reverse current when the fuel cell powerplants are switched into parallel operation. The circuit includes two transistors, two biasing resistors, and a hermetically sealed tantalum capacitor of 0.003 farads. The biasing of this circuit will also lessen ripple voltage. Breadboard tests of the circuit are planned for the latter half of August.

Development testing of the fuel cell subsystem in a vacuum environment is scheduled to begin in mid-August at S&ID.

Modification of the Westinghouse inverter is required for qualification tests. The electromagnetic interference (EMI) on the ac portion has been reduced to specification limits. Additional filtering is required for the dc side.

Qualification testing of the entry battery was begun at Eagle Picher; it is expected to be completed during September.

Electrical Wiring and Equipment

The environmental design criteria for the command module crew compartment were revised to require combined humidity-oxygen-salt spray qualification testing of all components. Bids are being solicited for these tests.

The first of six tests was conducted using two redundant pyrotechnic cutters to sever the command module-to-service module umbilical. The initial test successfully used four 100-grain per foot linear shaped charges and two booster charges. Both cutter charges were initiated simultaneously and propagated completely, resulting in a clean and even umbilical cut at both cutter locations. The heat shield interface showed no signs of damage of any kind. Figures 2 and 3 show the test setup and the test results. The next test, scheduled for mid-August, will use aluminum-backed cutters.

Electronic Interfaces

Packaging specifications are being developed for electronic units in the lower equipment bay of Block II vehicles to provide hermetic sealing to protect them against humidity. Procurement specifications for all display and control components are being revised to meet the reoriented qualification program and to incorporate revised and combined sequential environmental testing.

Annunciators and illuminated switches were redesigned to provide encapsulated lamps to conform with the deletion of inflight maintenance. The change will improve performance and reliability and eliminate the need for microminiature incandescent lamps.

PROPULSION SUBSYSTEM

Service Propulsion Subsystem (SPS)

11 firings of 5-baffle injectors were accomplished in the dynamic stability program during this report period. A second source is being developed for the fabrication of these injectors to relieve the workload of the electron-beam welding equipment at the subcontractor. Table 2 lists all firings conducted during this report period.

Installation of the engine mount in the F-3 test fixture at AEDC was begun, and the installation and calibration of instrumentation, including flowmeters, is under way. Test firings should begin in early October.

Reaction Control Subsystem (RCS)

The Phase II breadboard of the command module RCS was fabricated and assembled. Functional and leakage tests are in progress.

Postfiring inspection at Rocketdyne of a "workhorse" command module RCS engine showed that the soft liner, oriented at 45 degrees, was deteriorating too rapidly. Two additional workhorse engines were then fabricated with liners oriented at 6 degrees. These proved satisfactory, and this design will be incorporated in the qualification engine.

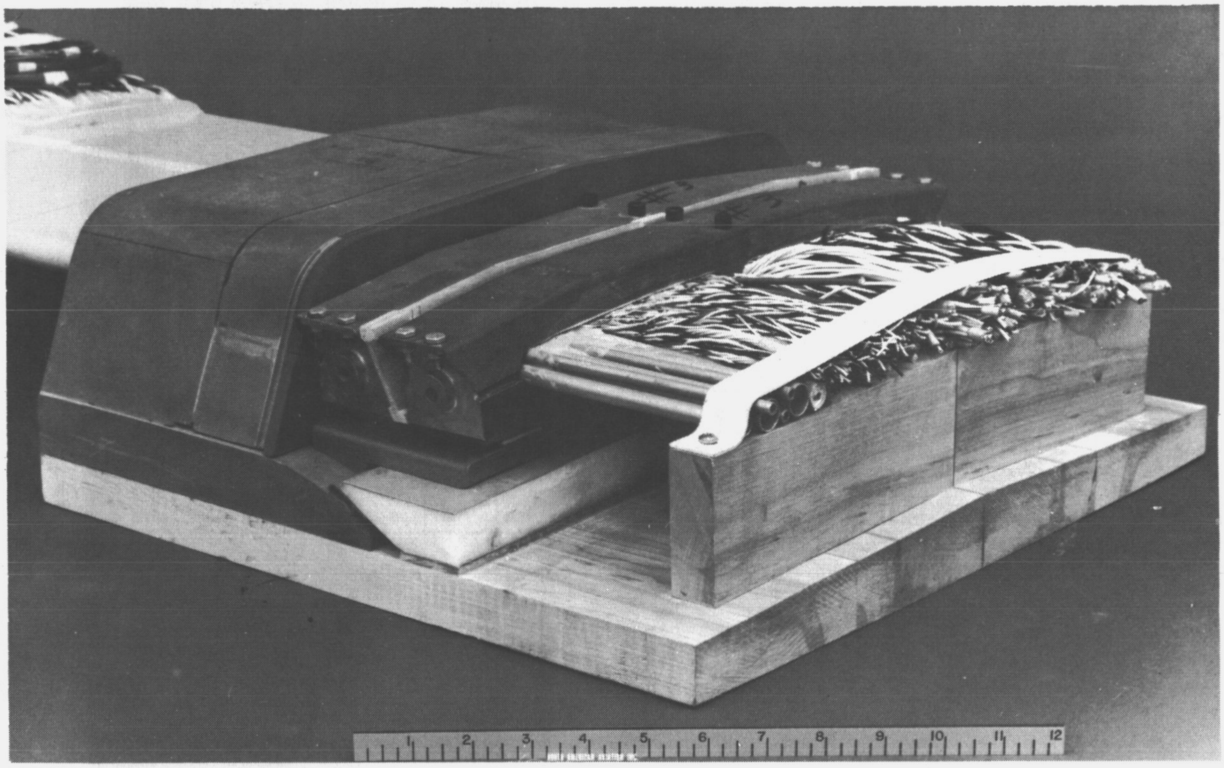

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Figure 2. Test Setup, Command Module-Service Module Umbilical

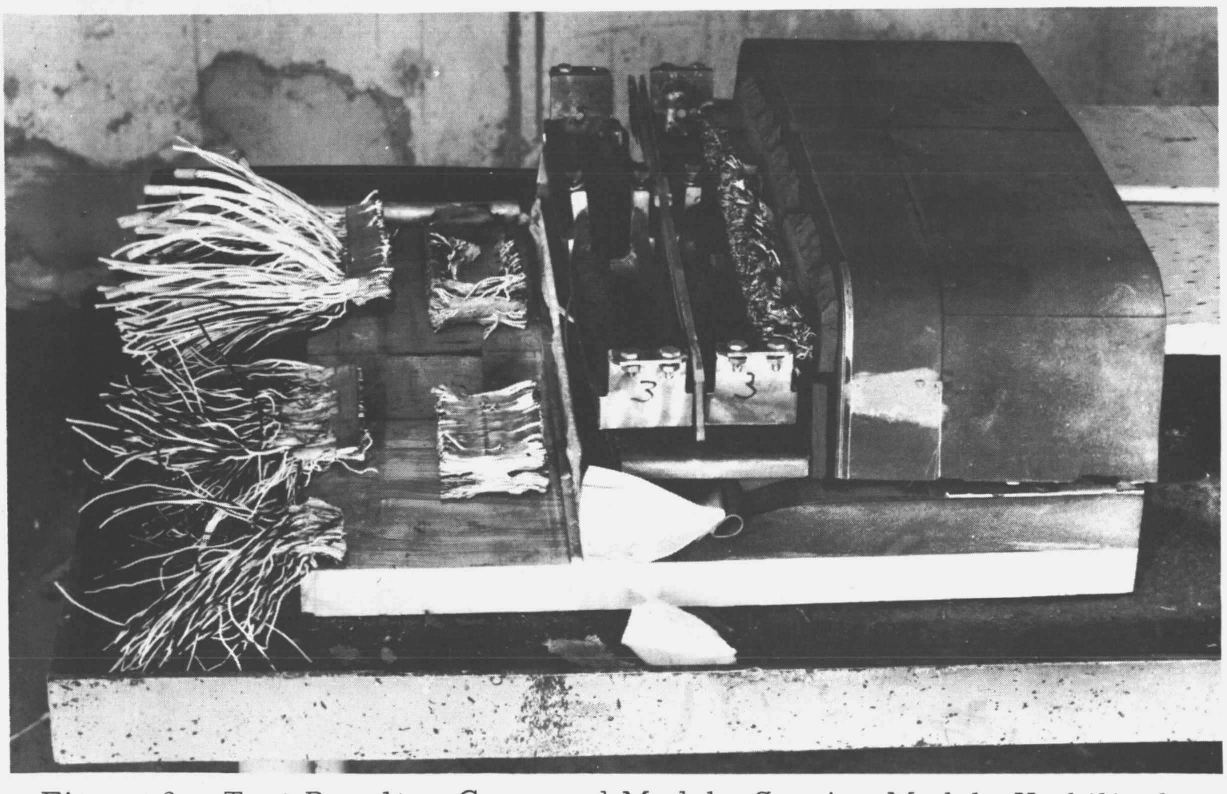

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Figure 3. Test Results, Command Module-Service Module Umbilical

Table 2. Apollo SPS Engine Test Program

Serial No.	Pattern Type	Type of Evaluation	Ablative Chamber		Steel Chamber		Remarks
			No. of Firings	Time (sec)	No. of Firings	Time (sec)	
0010 (5-4-4)	POUL-41-30	C*	2	41	3	16.5	"Popping" was experienced during 30-second ablative firing.
0011 (5-4-4)	POUL-41-32	C*			3	16.8	C* = 97.2
0013 (5-4-4)	POUL-41-26	C*			2	11.0	Satisfactory
		Pulse test			1	5.5	Satisfactory
AFF-40	POUL-31-37	C*			6	28.0	With resonator (acceptance test for engine assembly)
		Compatibility	1	31			Six minor streaks

C* = characteristic exhaust velocity

Design verification testing was completed successfully on the helium pressure vessel used in the RCS of both command and service modules. Qualification tests will begin at once.

The two-stage ignition concept for the service module RCS engine was tested at Marquardt, proving successful in the elimination of high ignition pressures. The development and qualification programs will be restricted to this ignition concept.

Launch Escape Subsystem

Tolerances of the resultant thrust vector angle of the tower jettison motor at sea-level were increased from 3.8±0.3 degrees to 3.0 degrees minimum and 4.5 degrees maximum. Two firings were made at 3.8 degrees, and the results confirmed predictions. Qualification test firing is scheduled to begin in mid-August.

Seven launch escape motors in the qualification program were successfully static-tested. Firing of the remaining 12 should be completed during August.

Four pitch control motors were delivered from Lockheed to Wyle Laboratories for acceleration tests and vibration tests.

The percent, by weight, of iron oxide to ammonium perchlorate was increased for the launch escape and pitch control motors from 31.00 to 32.75 percent. The change was made to provide sufficient ground oxidizer to achieve a burn rate within specifications. Two full-scale launch escape motors were cast with this new ratio.

Propulsion Analysis

Equipment was delivered to Wright-Patterson for the Phase A test of propellant motion in SPS tanks under zero-g conditions; it will be flown in a KC-135 aircraft. In the tests, 1/10, 1/17, and 1/34 scale models of the SPS tank will be rotated about various axes.

The temperature limits of the service module RCS engine were revised for Block I vehicles to reflect experimental results. Upper and lower limits are 400 F to 0 F for the injector valve, 130 F to 40 F for the oxidizer valve, and 250 F to 40 F for the fuel valve.

GROUND SUPPORT EQUIPMENT (GSE)

Acceptance Checkout Equipment (ACE-SC)

The second pulse code modulation (PCM) subsystem was received, completing the requirements for boilerplate 14. A new source was selected to meet the more severe environmental requirements of the carry-on PCM subsystem.

One set of ACE-SC hardware will be used on a share basis for boilerplate 14 and spacecraft 006. The number of signal conditioners required was substantially reduced for this set and for subsequent sets of ACE-SC hardware.

Special Test Units (STU)

Interim signal conditioners were assigned for all essential spacecraft measurements. These signal conditioners will be used with STU for initial testing of boilerplate 14. Measurement and stimuli data were submitted for the preparation of the automated STU measurement list. The computer program to obtain automated conversion plots for STU readouts is being completed. (The conversion is from percent of full scale to engineering units such as temperature, voltage, and pressure.)

A joint investigation by S&ID and Grumman revealed that, with minor modifications, the guidance and navigation (G&N) and radio frequency (RF) units of the STU can be adapted to the checkout of the G&N and RF subsystems of the lunar excursion module.

An intensive study of the utilization of the STU checkout subsystem resulted in the deletion of 7 STU models comprising 18 units. In addition, 21 units from other models were eliminated—a total of 39 STU deleted.

Bench Maintenance Equipment (BME)

The S-band, the C-band transponder, and the communications BME units (see Figure 4) were delivered for use at Downey to support boilerplate 14. These BME units will be operated manually to support acceptance testing or recertification of spacecraft equipment. They are capable of testing communications packages individually or together, as required, to verify performance and isolate malfunctions in replaceable spacecraft modules.

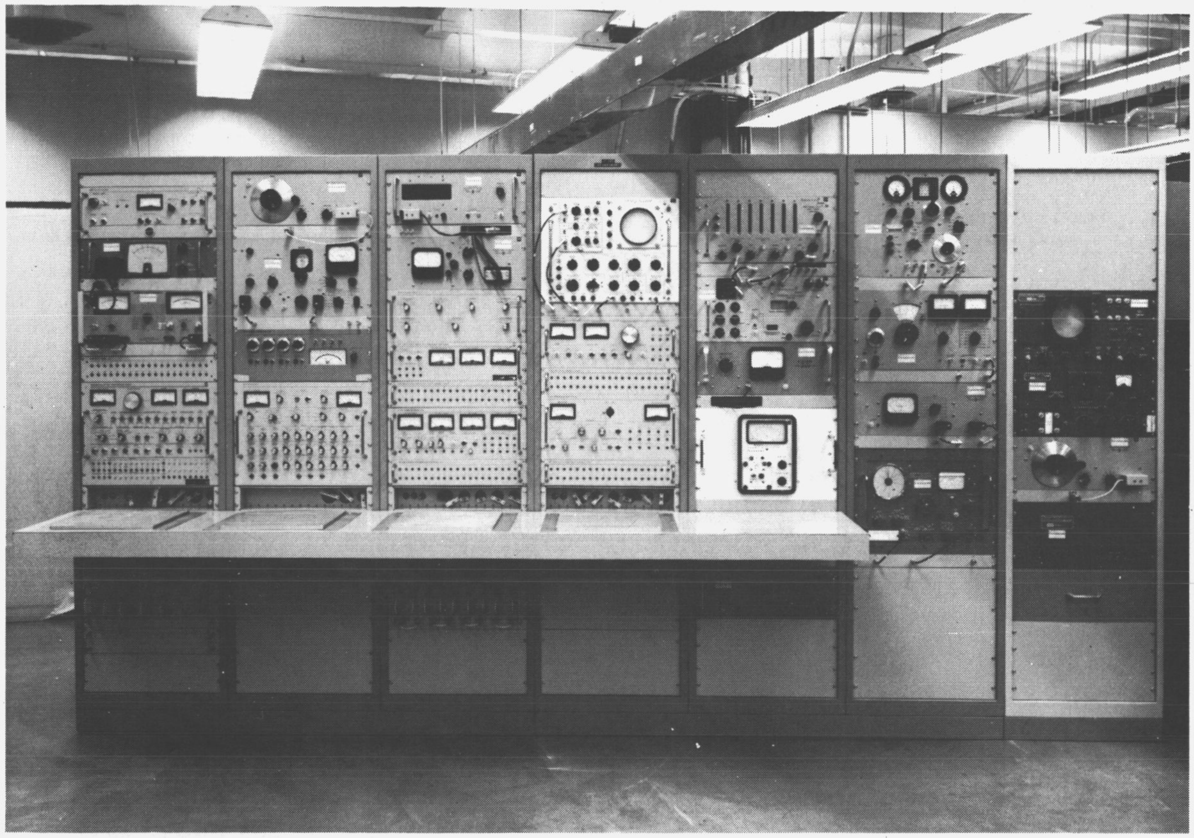

Figure 4. Communications Bench Maintenance Equipment

When the S-band BME and the communications BME are used in conjunction, the spacecraft S-band equipment can be operated with other communication and data equipment in a partial subsystem configuration.

The communications BME will support testing of the following spacecraft equipment:

VHF/AM transmitter receiver
HF transceiver
VHF/FM transmitter
VHF recovery beacon
Audio center
Premodulation processor

The first television BME unit was delivered to Downey to support checkout and performance verification of spacecraft television cameras. The second unit is in the process of acceptance testing by the subcontractor prior to direct shipment to NASA-MSC.

Spacecraft Instrumentation Test Equipment (SITE)

The fabrication of SITE at Autonetics was completed. Resolution of noise and of other minor technical problems is in process prior to acceptance tests.

COMSITE I, the compiler for SITE, is now operational. During this report period, 469 feet of punched tape were run for flight PCM package tests. COMSITE II is ready for final approval prior to coding.

SIMULATION AND TRAINERS

A contract was awarded for special computers and linkage equipment to be used in the analysis of the real-time simulation subsystem (RTSS). The supplier is proceeding with the development of the RTSS; subsystem design is nearly complete, and fabrication of long lead time items was begun. Future schedule milestones include subsystem integration and checkout beginning in early September, acceptance tests starting in late October, and delivery the first part of November.

The RTSS consists of a high-speed digital computer, 4 magnetic tape transports and a controller, a line printer, a card punch and reader, 3 input-output channels, 64 lines of priority interrupt, 64 channels of digital-to-analog and analog-to-digital conversion equipment, digital logic components, and 3 patch bays for digital, analog, and interrupt signals, respectively. The computer has the capability to store in its memory 32,768 words (each word consisting of 24 bits) with a speed capability of approximately 100,000 instructions per second. The instruction rate is based on a typical hybrid instruction mix for real-time simulation of the Apollo spacecraft. Introduction of the RTSS into the simulation complex will more than double the capability to do computation in real time. In addition, the basic capability required for the performance of sophisticated automatic checkout and data reduction routines will be available.

VEHICLE TESTING

GSE Projects

A detailed study is being made to identify the GSE equipment needed for each test phase of each test vehicle. The resulting visibility will allow more realistic scheduling, with work-around methods planned to support tests where required.

Development Flight Vehicles

The command modules of boilerplates 16 and 26 were air shipped to Kennedy Space Center (KSC) on August 11; the LES for these boilerplates will be shipped by truck on August 17. An early shipment of the boilerplate 27 command and service modules to MSC, Houston, can be made October 2 for structural dynamic tests prior to transshipment to MSFC, Huntsville. If an earlier shipment were required, however, the delivery could be made on September 9 without weight and balance check and without the lunar excursion module attach holes. The later date is recommended.

Development Ground Vehicles

Boilerplate 14 tubing and wiring harness are being installed according to the spacecraft 006 configuration. The fabrication, assembly, and engineering experience being gained on boilerplate 14 as an over-all development tool are being used in the engineering and fabrication of subsequent Apollo vehicles.

The spacecraft 006 command module heat shield (three sections) was fit-checked, removed, and shipped to Avco on July 24 on schedule. The crew compartment was then returned to the bonding facility for pickup bonding efforts. The service module was removed from the structural assembly fixture and is now in the pickup jig for structural pickup efforts before the secondary structure installation.

Fabrication of boilerplate 28 entered the final stages with the fitting of the equipment bay shelf assembly and crew couch side attenuation structure. The command module crew side walls were installed, the command module-to-aft heat shield fit-check was completed, and attach holes were drilled. The aft heat shield ballast installation was begun.

Approximately 95 percent of the spacecraft 001 EPS and cryogenic subsystem tubing was fabricated, and 75 percent was installed and brazed in the vehicle. 16 of the 17 vehicle wiring harnesses were completed and installed in the vehicle. Mock-up of the SPS helium pressurization panel and the RCS panels was completed.

Fabrication of detail parts was continued on spacecraft 004 and 007. Several major weldments were completed on spacecraft 007. These included weld of the crew compartment inner aft bulkhead to the aft sidewall, welding of the 1/4 and 3/4 sections of the crew compartment structure, and welding of the crew compartment forward and aft heat shield sections. On spacecraft 004, the crew compartment 1/4 section weldment was completed.

RELIABILITY

An evaluation was made of five proposed configurations for an inflatable bag to achieve single-point flotation stability of the command module. Table 3 lists the five configurations.

Table 3. Proposed Inflatable Bag Configurations

Configuration	Inflation Source	Inflation Supply	Operation
I	High-pressure tank (4500 psi)	Nitrogen	Manual switch operates a pyro valve to inflate bag.
II	Same as Configuration I	Carbon dioxide	Same as Configuration I
III	Electric motor/blower unit	Air	Manual switch energizes motor.
IV	Gas generator/ jet pump (venturi)	Air and hot gas	Air and hot gas provide cooling and reduce gas generator charge. Air is bled into the jet pump through an outside air vent.
V	Gas generator	Hot gas	Hot gas is cooled by a cooling coil submerged in the ocean.

Configuration III, the electric motor and blower subsystem, shows considerable promise, because it uses no high-pressure source and has the advantage of potential reinflation in case the bags leak. One disadvantage, the electrical power drain, is being investigated.

Configurations IV and V are second-choice, but are undesirable in view of the high pressure (about 3000 psi) used for inflation, which could result in damage or broken lines at impact.

Configurations I and II are unacceptable because of the danger of a high-pressure tank aboard the command module at impact.

Several qualification tests of Block I SCS are scheduled to begin in late August to support unmanned spacecraft 009 and 011. Two additional equivalent subsystems will be used, after EMI and humidity fixes are incorporated, to support potentially manned spacecraft 008, 012, and subsequent vehicles.

The Block II general philosophy to be used in the construction of the integrated guidance and control reliability logic was established. For the preliminary logic, it was assumed that the requirements for failure detection and new lunar excursion module and command and service module interfaces would not be considered. The mission functions and reliability logic diagrams were reviewed. Honeywell was requested to determine the functional groupings of the SCS that would be needed for incorporation into the Block II integrated guidance and control and over-all spacecraft electronics logic, and to derive the failure rates for those functional groupings. Updated SCS logic and failure rates will be evaluated for adequacy in meeting the 0.984 mission success requirement.

Minimum airworthiness testing for boilerplate 23 is to include the following tests on the canard subsystem:

1. Limit load tests involving the latch mechanism at maximum opening and design loads
2. Sinusoidal vibration
3. Operational tests consisting of three ordnance actuations of the canard

The above tests conform to and are a part of the environmental tests required for qualification.

INTEGRATION

Analysis of boilerplate 13 flight data confirmed earlier indications that the flight was highly successful. The data covered 96.5 percent of the scheduled measurements, and the quality was good. Electromagnetic interference was detectable on certain telemetry channels, but it did not degrade or invalidate the data.

The cause of the apparent malfunction of the ECS pump-assembly could not be determined. Corrosion and bearing failure are possible causes. The malfunction reduced the life of main battery B; the subsystem performed satisfactorily, however, in cooling the communications equipment. The performance of the flight batteries was excellent, exceeding expectations.

Tower jettison was satisfactory, and no resultant disturbance of the flight vehicle was detected. The sequencer subsystem, the explosive bolts, and the tower jettison motor all functioned properly.

The aerodynamic, thermodynamic, acoustic, vibration, and modal frequency data were all in general agreement with those predicted.

As expected, the loads imposed on the LES were considerably less than those imposed by abort modes. Loads on the other spacecraft structures were all within design limits.

Vibration is considered to be the most probable cause of the failure of three calorimeters and one vibration sensor.

"Project Apollo, Flight Test Report, Boilerplate 13" (SID 63-1416-3) contains a detailed evaluation of the flight.

The July mock-up review of spacecraft 011 represented significant progress in clearing up requests for changes (RFC) generated during the April mock-up review. With the exception of one or two small items, all carry-over RFC's were satisfactorily reworked. Figure 5 shows the interior of command module mock-up 2; the upper portion of the boost protective cover is installed. This is the first proposed installation of the upper portion of the boost protective cover on the command module.

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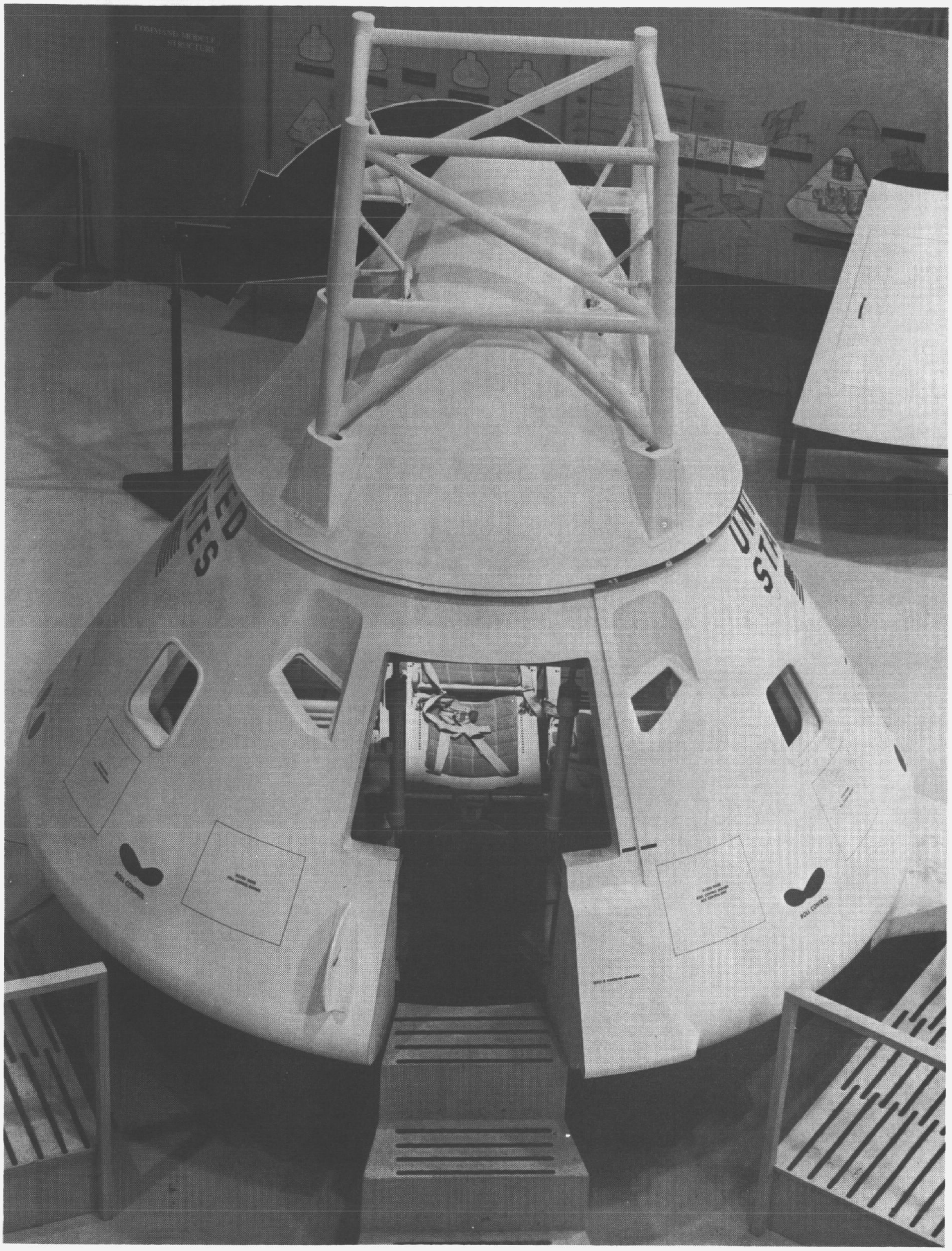

Figure 5. Command Module Mock-up 2

OPERATIONS

DOWNEY

Boilerplates 16 and 26

The weight and balance tests on boilerplates 16 and 26 were completed satisfactorily. Stacking and alignment were accomplished on each vehicle with its launch escape tower. Upon completion of the tests at Downey, the launch escape subsystem (LES) for each vehicle was disassembled and crated. Both command modules were repainted and shipped to the Florida facility. The boilerplate 16 LES was shipped on August 14 and the boilerplate 26 LES is to be shipped on August 17.

Boilerplate 23

The boilerplate 23 service module was delivered to Test and Operations on July 27. Delivery of the command module and launch escape tower was accomplished on July 28. Stacking operations in the tower were completed, and checkout of the individual systems was begun. To date, checkout has been completed on the radar beacon and telemetry system antenna, the on-board tape recorder, the electrical power distribution system, the radar beacon system, the sequencers for the earth landing system and launch escape system, the earth landing system barometric switch, and the telemetry ground station.

Boilerplate 23 mission readiness testing will be completed during the next report period. The vehicle will then be demated and prepared for shipment to White Sands missile range (WSMR).

Boilerplate 22

The detailed test plan and the checkout procedures for boilerplate 22 will be completed and published during the next report period.

Boilerplate 14

Boilerplate 14 checkout procedures will be updated or written to implement the cockpit control checkout concept. Boilerplate 14 will be received by Test and Operations on August 28.

WHITE SANDS MISSILE RANGE

Propulsion System Development Facility (PSDF)

The test fixture F-2 high-pressure section functional check was completed on July 17. The subcontractor effort on the installation of the fluid distribution system was completed on July 19. 15 major modifications and 26 pickup items are in progress to complete system installation by August 31.

Components of the heat exchanger and associated equipment were shipped to the Los Angeles division for cleaning. All components were then returned to the PSDF for installation. Heat exchanger modification and installation is to be completed by August 20.

Components of the F-2 engine and associated equipment were cleaned. Installation of the engine in the test fixture was accomplished on August 6. Hookup of the engine interfaces is to be completed by August 17. Installation and validation of the fuel and oxidizer transfer units was completed. Repair of the toxic vapor disposal units was completed.

The hookup of all F-2 engine interfaces will be completed by August 17.

Modification and installation of the fluid distribution system will be completed. This system will be validated by August 31.

Validation will be performed on the fuel transfer unit, the fuel and oxidizer ready storage units, the fuel and oxidizer toxic vapor disposal units, and the decontamination unit.

Mission Abort

Modification of the GSE to support operations with boilerplate 23 will be continued during the next report period. Launch complex 36 will be modified for compatibility with the GSE changes.

Grain inspection of the launch escape motor will be conducted, and the skirt will be installed. Buildup of the boilerplate 23 LES will be started.

FLORIDA FACILITY

Boilerplate 15

Buildup of boilerplate 15 LES and installation of the electrical harness were completed on July 22. Modification of the LES weight and balance fixture was completed, and the LES weight and balance determination was accomplished on July 27. The LES was transported to the Mark VI ordnance storage building on July 29.

The spacecraft-launch vehicle electrical interface checks were successfully completed on August 7. During this check, the spacecraft LES arm sequence was operated while the launch was monitored, and the launch vehicle sequencers were operated while the spacecraft was monitored; no problems were encountered.

The launch vehicle sequencer malfunction checks, demonstrating and verifying spacecraft-launch vehicle interface compatibility were completed on August 12. A circulation check of the boilerplate 15 environmental control subsystem was conducted in parallel with the launch vehicle sequencer malfunction checks; no problems were encountered.

Launch checkout and test operations with boilerplate 15 will be continued at pad 37B toward an end-date of field operations scheduled for September 15. The LES is to be mated to the command module on August 16. The first over-all spacecraft-launch vehicle test (with umbilical plugs in) will be performed followed by the spacecraft-launch vehicle radio frequency interference tests on August 24. The second over-all spacecraft-launch vehicle test (with umbilical plugs out) will then be completed. The spacecraft-launch vehicle simulated flight will be conducted on September 9.

Boilerplates 16 and 26

The command module and LES for boilerplates 16 and 26 will remain in storage until after mid-September, when S&ID will begin limited field checkout and test operations.

FACILITIES

DOWNEY

Impact Test Facility

The supplemental agreements approving funds to enlarge the test pool were received on July 30, 1964, and immediate steps were taken to put this project under contract. Completion will be expedited to meet schedule. The estimated completion date is October 12, 1964, to support the engineering development laboratory test schedule for boilerplate 28. The pool will be enlarged by 3600 square feet, and the depth will be increased to 20 feet. This modification will accommodate the revised test requirements established by NASA, which increase the maximum horizontal velocity from 35 fps to 48 fps and specify other test conditions associated with the criterion of water impact as primary mode.

Tube Processing Facility

A contract was awarded and construction has begun on the extension to house the salt bath brazing facility. Construction is scheduled to be complete on September 14, 1964. This will provide dip brazing process capability for aluminum and steel tubing with special joint configurations and high reliability requirements.

Space Systems Development Facility (SSDF) Vibration System

Vibration systems believed to be the largest ever built have been delivered to the space systems development facility of the engineering development laboratory. Two 100,000-pound shaker systems were delivered by the Vard Division of Royal Industries on July 16, 1964. Installation, checkout, and acceptance testing of this system is scheduled for completion by October 15, 1964.

Budgetary and Planning Appendixes, GFY 1966 to 1970

The budgetary and planning facility estimates for GFY 1966 to 1970 have been completed and submitted to NASA.

APPENDIX

S&ID SCHEDULE OF APOLLO MEETINGS AND TRIPS

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S&ID Schedule of Apollo Meetings and Trips
July 16 to August 15, 1964

Subject	Location	Date	S&ID Representatives	Organization
Contract negotiations	Houston, Texas	July 16 to 22	Cleworth, Hamilton	S&ID, NASA
Parachute drop tests, monitoring and observation	El Centro, California	July 17 to August 13	Ames	S&ID, Northrop
Signal Conditioning Equipment Acceptance Test, Witnessing	Cedar Rapids, Iowa	July 19 to 25	Himmelberg	S&ID, Collins
Boilerplate 23 review meeting	White Sands, New Mexico	July 19 to 24	Young	S&ID, NASA
Intercom system meeting and discussion	Houston, Texas	July 20 to 21	Ellis	S&ID, NASA
Facilities inspection	Grand Prairie, Texas	July 20 to 22	Jay	S&ID, Ling-Temco-Vaught
Use of Ling thruster installation on large package application test, investigation	Pittsburgh, Pennsylvania	July 20 to 23	Houts	S&ID, Westinghouse
Implementation of revisions, discussion	San Carlos, California	July 20 to 24	Lazarus, Langager, Castner	S&ID, Pelmec
Project engineering coordination meeting	Sacramento, California	July 20 to 24	Mower	S&ID, Aerojet
Program status review	Elyria, Ohio	July 20 to 30	Butler	S&ID, Lear-Siegler
Project engineering coordination meeting	Houston, Texas	July 21 to 22	Kennedy, Robins	S&ID, NASA
Earth landing subsystems, meeting	Houston, Texas	July 21 to 23	Young, Lowry	S&ID, NASA
Spacesuit mobility notation systems, meeting	Bethpage, L.I., New York	July 21 to 24	Roebuck	S&ID, Grumman
Expulsion tanks, technical status review	Buffalo, New York	July 21 to 24	Gibb, Wagner, Hobson	S&ID, Bell
Block II scientific equipment resolution, discussion	Houston, Texas	July 22 to 23	Walkover	S&ID, NASA
Ground rule coordination meeting	Minneapolis, Minnesota	July 22 to 24	Antletz, Radeke	S&ID, Honeywell
Dynamic motion simulator engineering coordination	Shawnee, Oklahoma	July 22 to August 7	Weir	S&ID, Shawnee Industries
Motor switch problem resolution	Solana Beach, California	July 24 to 27	Schoenbach	S&ID, Kinetics

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S&ID Schedule of Apollo Meetings and Trips
July 16 to August 15, 1964 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Maximum design weight discussion	Houston, Texas	July 27 to 28	Dodds, Vucelic, Young	S&ID, NASA
Future plans for acceptance testing of flight table review status	Shawnee, Oklahoma	July 27 to 29	Kerr, Dudek	S&ID, Shawnee Industries
Vehicle ground operations specifications, coordination meeting	Cape Kennedy, Florida	July 27 to 29	Courtis	S&ID, NASA
Mechanical integration panel meeting	Houston, Texas	July 27 to 29	Tooley	S&ID, NASA
Test and operations coordination meeting	Houston, Texas	July 27 to 29	Pearce	S&ID, NASA
Prelaunch spacecraft-lunar excursion module plan of action study	Bethpage, L.I., New York	July 27 to 30	Lu	S&ID, Grumman
Engineering coordination meeting	Houston, Texas	July 27 to 30	Kitakis, Marshall, Bruggeman	S&ID, NASA
Interface coordination meeting	Houston, Texas	July 27 to 31	Dziedziula, Jobson	S&ID, NASA
Humidity redesign meeting	Melbourne, Florida	July 27 to 31	Dorrell	S&ID, Radiation
Project engineering coordination meeting	Sacramento, California	July 27 to 31	Mower	S&ID, Aerojet
Boilerplate 23 operations meeting	White Sands, New Mexico	July 27 to 31	Lee	S&ID, NASA
Change control procedures review	Houston, Texas	July 28 to 29	Harrington	S&ID, NASA
Change procedure meeting	Houston, Texas	July 28 to 29	Drucker	S&ID, NASA
Engineering changes consideration meeting	Cedar Rapids, Iowa	July 28 to 29	Moore	S&ID, Collins
Engineering coordination meeting	Shawnee, Oklahoma	July 28 to 29	Sorensen	S&ID, Shawnee Industries
Component detail design changes, review	Sacramento, California	July 28 to 30	Cadwell	S&ID, Aerojet
Soldering specifications, resolution of differences	Houston, Texas	July 28 to 30	Whiting, Martin	S&ID, NASA
Program status review	Minneapolis, Minnesota	July 28 to 31	Saindon	S&ID, Control Data

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S&ID Schedule of Apollo Meetings and Trips
July 16 to August 15, 1964 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Daily impact report meeting	Cedar Rapids, Iowa	July 28 to 31	Blakeley	S&ID, Collins
Technical deletions, discussion	E. Hartford, Connecticut	July 28 to 31	Nash	S&ID, Pratt & Whitney
Vibration failures of Block I, technical meeting	Minneapolis, Minnesota	July 29 to 30	Rose	S&ID, Honeywell
Service module propulsion rocket engine, delivery status meeting	Sacramento, California	July 29 to 30	Barker, Field	S&ID, Aerojet
Component detail design, review of changes	Sacramento, California	July 29 to 30	Field	S&ID, Aerojet
Acceptance test, discussion of procedures and problems	Minneapolis, Minnesota	July 30 to August 7	Ullery	S&ID, Rosemount Engineering
Routine inspection trip and observation of test results	Goleta, California	July 31	Richardson	S&ID, General Motors
Test data procedures, review	Buffalo, New York	August 2 to 23	Burge	S&ID, Bell
Crew safety panel meeting	Houston, Texas	August 3 to 4	Hafner	S&ID, NASA
SPS systems briefing, presentation	Houston, Texas	August 3 to 5	Field, Bratfisch	S&ID, NASA
Electrical interfaces and transponder antenna design, coordination meeting	Bethpage, L.I., New York	August 3 to 5	Bond	S&ID, Grumman
Project engineering coordination meeting	Sacramento, California	August 3 to 7	Mower	S&ID, Aerojet
Command module delivery coordination	Lowell, Massachusetts	August 4	Smith	S&ID, Avco
Block I thrust vector control, redundancy problem review	Minneapolis, Minnesota	August 5	Geheber	S&ID, Honeywell
Interference subpanel meeting	Houston, Texas	August 4 to 6	Chambers, Pumphrey	S&ID, NASA
Lunar excursion module display and control lighting, design, and mock-up review meeting	Bethpage, L.I., New York	August 5 to 7	Nelson, Olesen, Troolines, Smith	S&ID, Grumman, NASA

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S&ID Schedule of Apollo Meetings and Trips
July 16 to August 15, 1964 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Central timing equipment review	Rolling Meadows, Illinois	August 6 to 7	Mihelich	S&ID, Elgin
Test plan coordination meeting	Houston, Texas	August 10	Larson, Howard, Altenbernd	S&ID, NASA
Lunar excursion module interface meeting	Bethpage, L.I., New York	August 10 to 12	Neatherlin, Brewer, Hughes, Gilmore	S&ID, Grumman
Program progress review meeting	Philadelphia, Pennsylvania	August 10 to 13	Perry, Cypert, Petak	S&ID, Aero Service
Project engineering direction of field activities on boilerplate 15	Cocoa Beach, Florida	August 10 to 29	Condit	S&ID, NASA
High-gain antenna technical problems, coordination and review	Valley Forge, Pennsylvania	August 11 to 12	Ross	S&ID, General Electric
Project engineering coordination	Cape Kennedy, Florida	August 11 to 13	Siwolop	S&ID, NASA
Quality control requirements, discussion	Sacramento, California	August 11 to 13	Cadwell	S&ID, Aerojet
Technical approach and schedule definition. meeting	Bethpage, L.I., New York	August 11 to 13	Lopez	S&ID, Grumman
Producing inverters technical problems resolution and review	Lima, Ohio	August 11 to 14	Champaign, Young	S&ID, Westinghouse
Bimonthly engineering coordination meeting	Boulder, Colorado	August 11 to 15	Bouman	S&ID, Beech
Task force interface meeting	Houston, Texas	August 12 to 14	Kitakis	S&ID, NASA